Translating Pollution Prevention into Health, Mortality, and Other Environmental Benefits

Domestic Co-Benefits from Adoption of Clean Energy Policies to Reduce Greenhouse Gas Emissions

Renewable Energy Modeling Series – Modelers' Working Group

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Introduction

- Roughly 80% of GHG emissions are by-products of fossil fuel combustion processes that also generate "conventional" air pollution emissions (NOx, PM, SO2, VOC, NH_3).

- Policies that reduce CO_2 emissions often involve energy efficiency and fuel switching strategies that likewise reduce emissions of criteria pollutants.

- These emission reductions result in improvements in domestic air quality benefits other than CO_2 reductions.

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Analysis of Domestic Benefits in terms of:

- Conventional pollutant emission reductions
- Cost savings of implementation of the $PM_{2.5}$ NAAQS
- Ambient air quality improvements
- Reduced mortality
- Reductions in nitrogen deposition into east-coast estuaries
- Visibility improvements

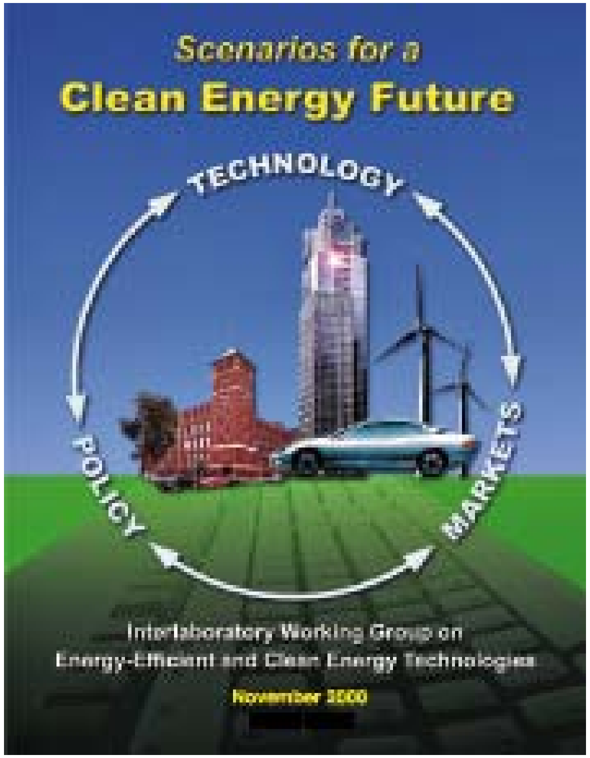
Climate Policies Evaluated

- Clean Energy Future (CEF) Study
- Sponsored by U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy

  Interlaboratory Working Group. 2000. Scenarios for a Clean Energy Future (Oak Ridge, TN; Oak Ridge National Laboratory and Berkeley, CA; Lawrence Berkeley National Laboratory), ORNL/CON 476 and LBNL-44029, November.

  http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm

- Two Potential Climate Policy Scenarios Analyzed over the period of 1997 to 2020: MODERATE and ADVANCED
- CEF Study provided energy use by sector, fuel, and region. Co-benefits analysis focuses on emissions outcomes modeled in 2010

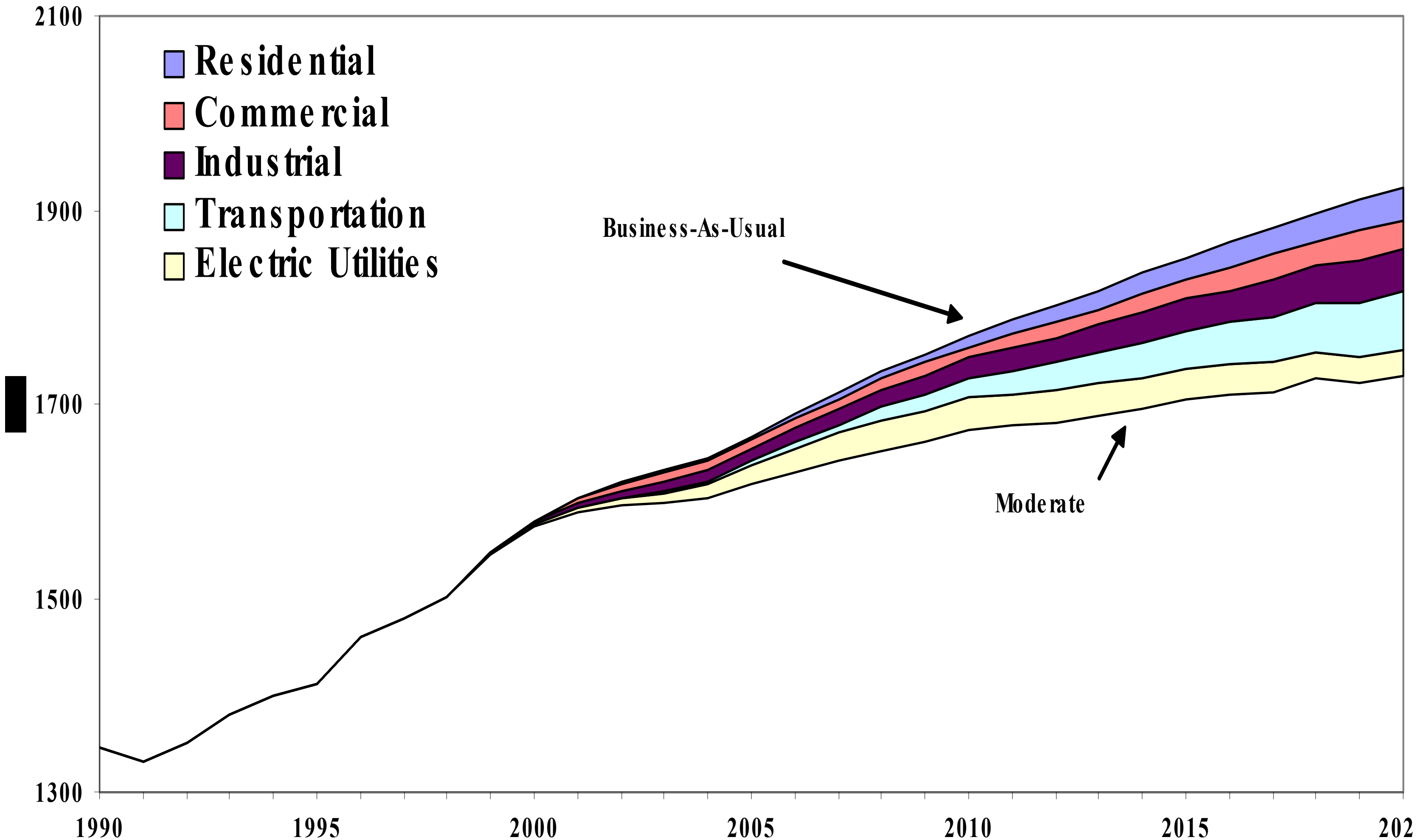


Moderate CEF Scenario

- Supported by policies that lower carbon emissions by 85 MtC (5%)
- Are not highly controversial today
- Generally have no increased net direct cost to the customer
- Would not impose significant direct costs on any single region or sizable group
- Would not involve new fiscal policies that tax energy, either directly or indirectly

Defined by combinations of policies such as information outreach efforts, enhanced R&D, government procurement programs, voluntary industry agreements, technical assistance, stricter codes and standards, rebates, and tax credits

Moderate CEF Scenario



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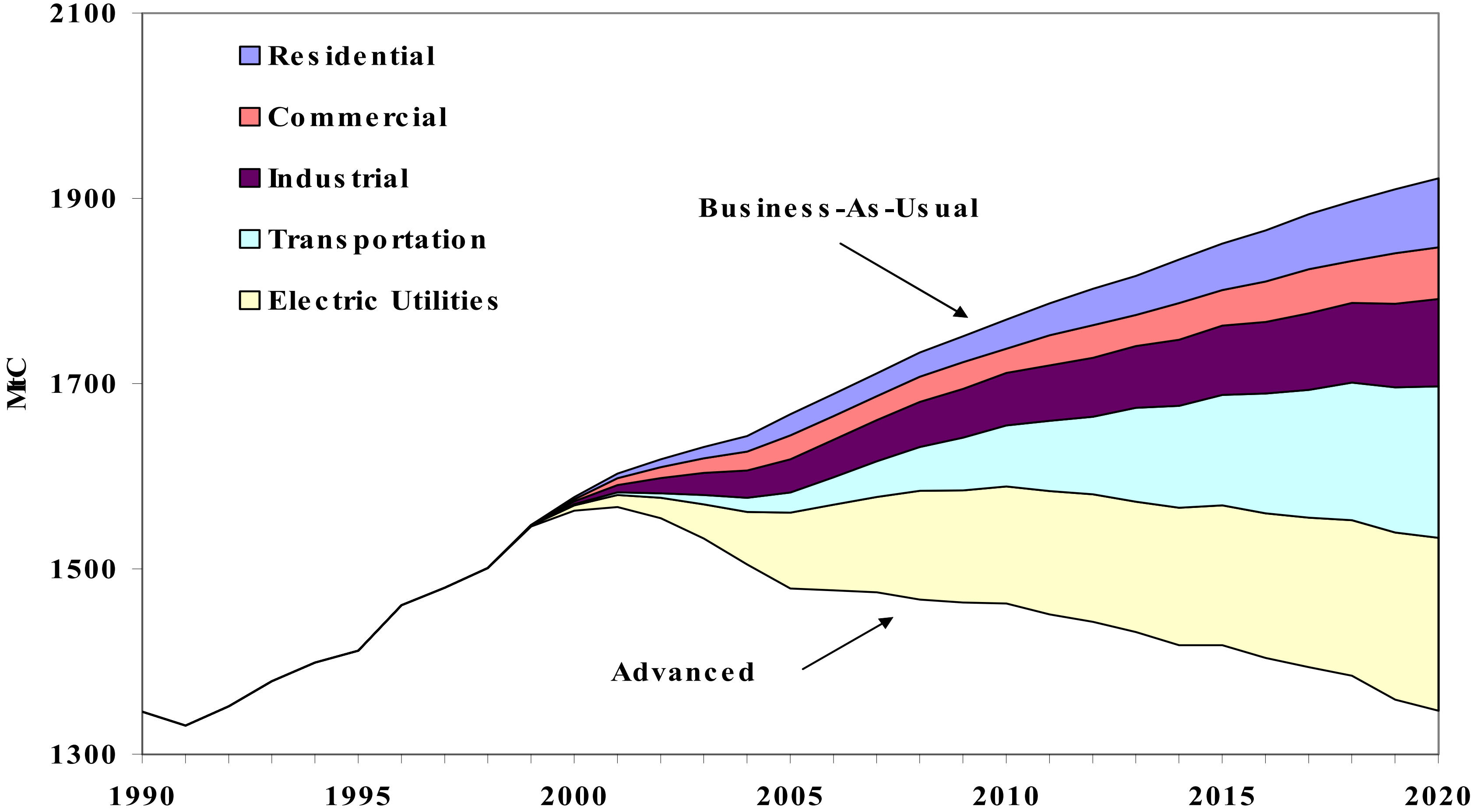
Advanced CEF Scenario

- More aggressive set of energy efficiency and carbon policies that lower carbon emissions by 306 MtC (17%)
- Include all of the Moderate scenarios policies or more stringent versions of the same
- May be highly controversial today
- May have net direct cost to the customer up to $50/ton
  (although with energy savings benefits that offset much of that cost)
- May impose significant direct costs on one ore more regions or sizable group
- Includes a domestic carbon trading system

One key difference is the Advanced scenario establishes a system for the trading of carbon permits within the United States

Advanced CEF Scenario



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Projected 2010 Primary Energy Consumption

Sector	Fuel Type	2010 Clean Energy Scenario (Quadrillion BTU)		
		Business as Usual	**Moderate**	**Advanced**
Utility	Coal	21.2	19.9	14.2
	Natural Gas/Petroleum	6.9	5.0	6.2
Industrial	Coal	2.3	2.2	1.9
	Natural Gas	13.5	13.0	12.4
	Petroleum	8.3	7.9	7.4
Residential	Coal	0.1	0.1	0.1
	Natural Gas	6.0	5.9	5.7
	Petroleum	0.8	0.8	0.8
Commercial	Coal	0.1	0.1	0.1
	Natural Gas	3.9	3.9	3.8
	Petroleum	0.5	0.5	0.5
Transportation	Gasoline	18.7	18.1	16.2
Total	**Fossil Fuels in EPA Study**	**82.1**	**77.3**	**69.1**
Other Energy Use	Nuclear, Renewables, Other	28.2	29.2	30.2

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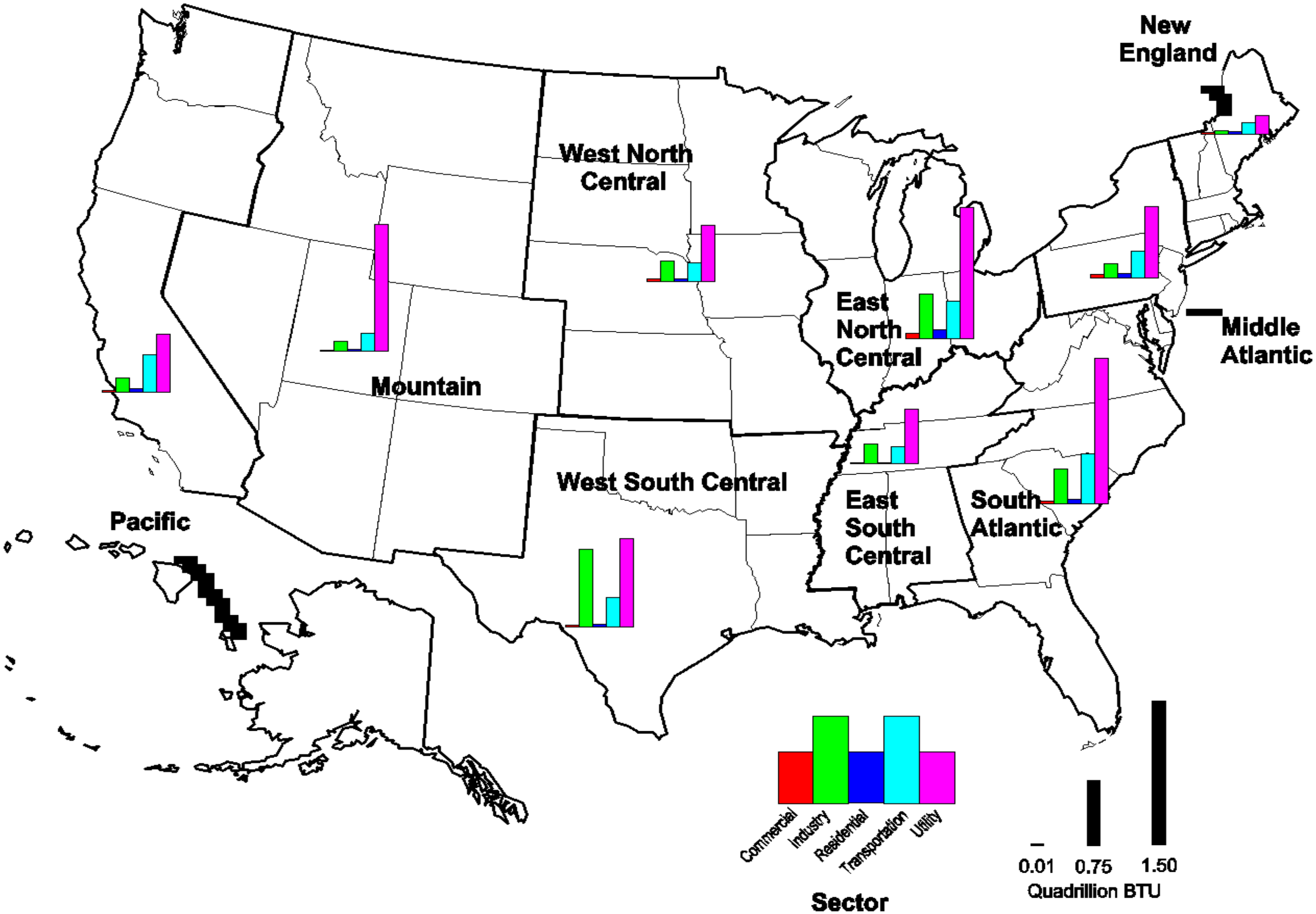
Advanced CEF Scenario - Energy Consumption Change



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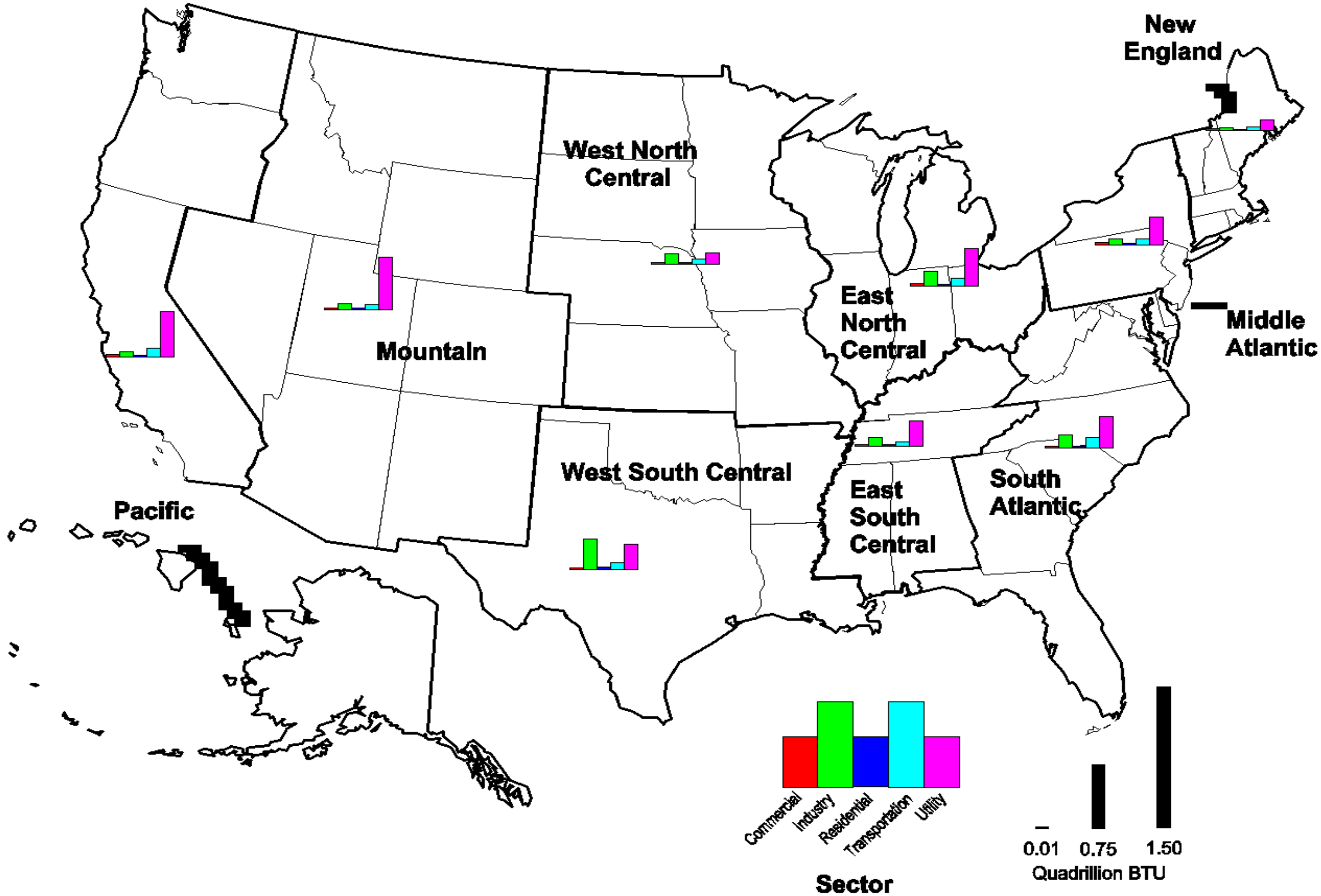
Moderate CEF Scenario - Energy Consumption Change



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“Conventional” Pollutant Emission Reductions

- Emission reduction estimates based on 2010 National emission estimates developed for EPA and % changes in energy consumption usage of fossil fuels between a BAU and climate scenario

- Changes in emissions are estimated for the utility, industrial, residential, and commercial sectors for coal, oil, and natural gas combustion sources only

- Results assume the U.S. will partially attain the $PM_{2.5}$ and 8-hr ozone National Ambient Air Quality Standards prior to implementation of Climate Policy (i.e., composite scenario developed)

- Apportions CEF emission reductions into benefit and credit tons
  - Credit tons – reductions that would have occurred under the new NAAQS, regardless of climate policy. Converted to dollar savings and essentially offset control cost of NAAQS implementation
  - Benefit tons – reductions that would not have occurred but for implementation of climate policy

Estimated Emission Benefits and Credits of NAAQS and CEF Scenarios in 2010 (in tons)

	Reduction tons due to			*Carbon Policy Pay-off*		
Pollutant	New PM and O3 NAAQS	CEF Scenario		Credit Tons	Benefit Tons	Cost Savings ($ million)
Moderate CEF Scenario						
SO_2	5,758,054	721,534		573,220	148,314	346
NOx	658,536	374,599		90,458	284,140	118
PM_{10}	3,688,431	32,714		2,657	30,057	7.4
PM_{25}	870,096	18,794		1,503	17,290	-
VOC	781,462	12,679		998	11,681	2.8
						474.2
Advanced CEF Scenario						
SO_2	5,758,054	3,888,120		3,308,761	579,359	1,980
NOx	658,536	1,534,964		375,071	1,159,893	494
PM10	3,688,431	117,910		10,770	107,140	29
PM25	870,096	49,866		4,492	45,375	-
VOC	781,462	23,678		2,151	21,527	6
						2,509

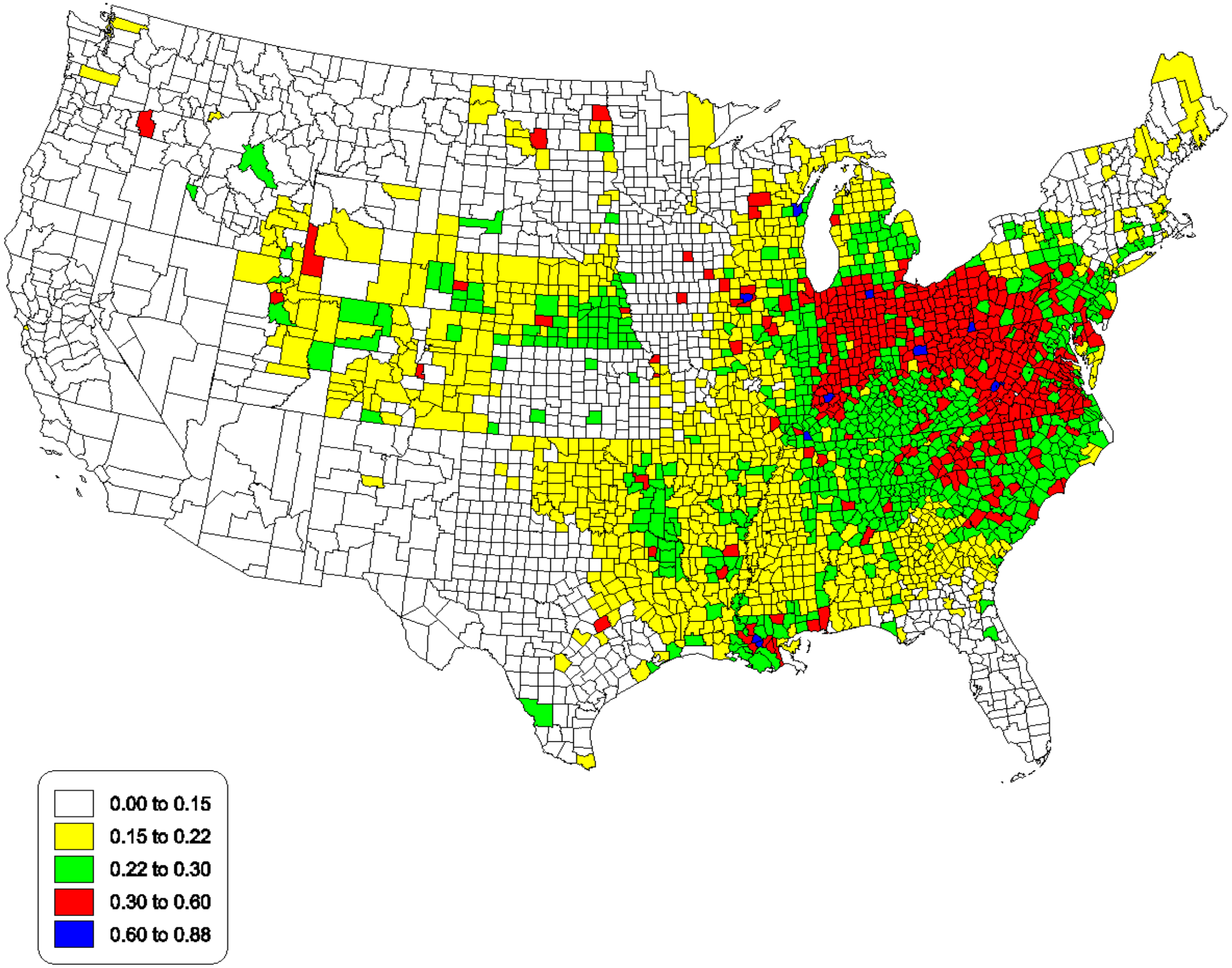
Ambient Air Quality

- Criteria pollutant emissions are used as inputs to an air quality model that relates pollutant emissions to county-level ambient concentrations

- The method utilized a source-receptor matrix to convert emissions (tons/year) into ambient pollutant concentrations ($\mu g/m^3$) at a each U.S. county

- Model outputs include county-level annual average concentrations of primary PM_{10}, primary $PM_{2.5}$, ammonium nitrate, ammonium sulfate, primary organic carbon, primary elemental carbon, biogenic organic aerosol, and secondary organic aerosol

Advanced CEF Scenario – Change in Annual Average PM2.5 Concentration (µg/m³)



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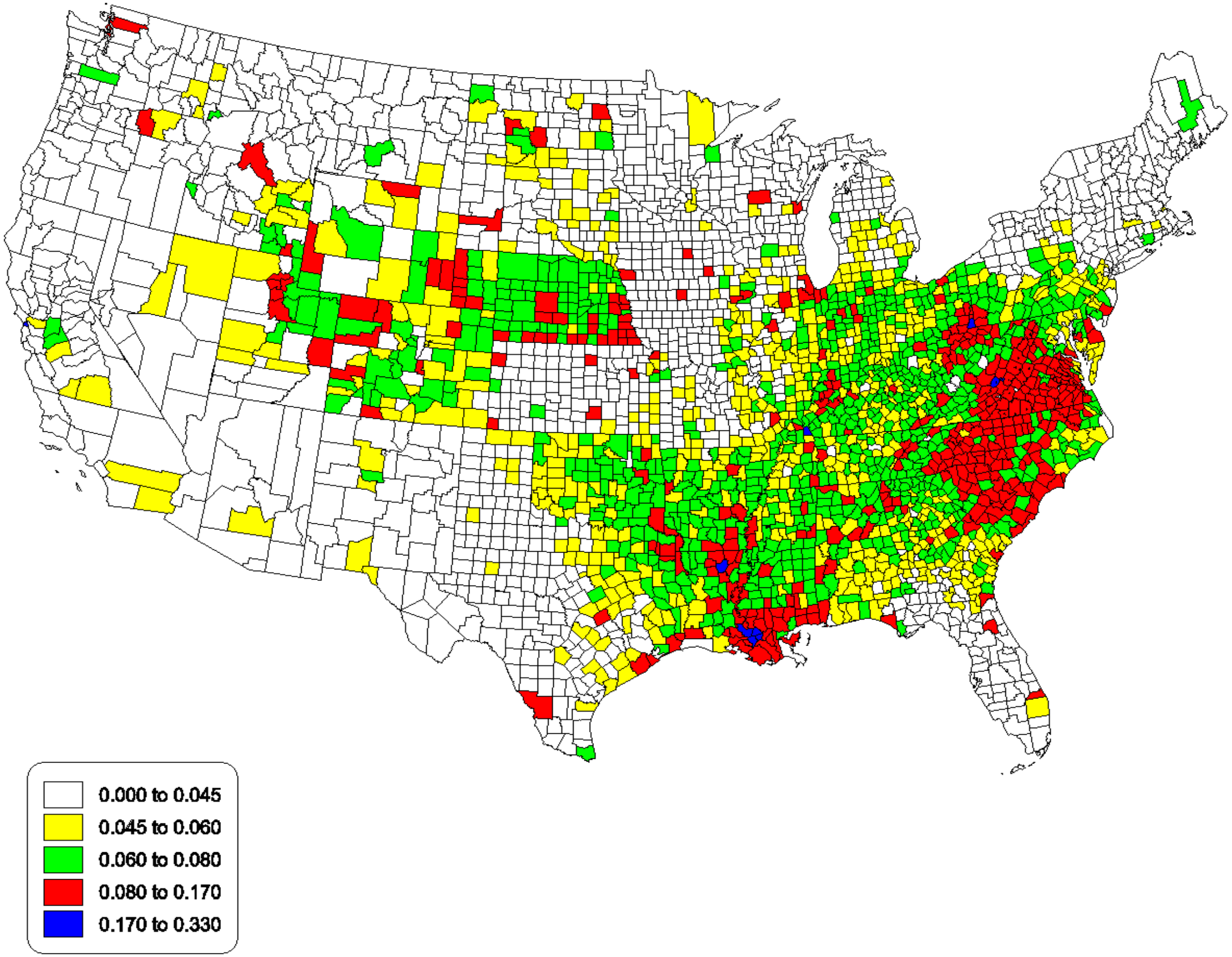
Moderate CEF Scenario – Change in Annual Average $PM_{2.5}$ Concentration ($\mu g/m^3$)



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Excess Mortality

- Excess mortality estimated using a concentration-response (C-R) function based on changed in population weighted $PM_{2.5}$ concentrations by county
- Concentration-response function is from the Krewski et al. (2000) re-analysis of the Pope et al. (1995) Study
- Results:
  - Change in Mortality
    - Advanced CEF Scenario = -1,981 ($9.9 billion)
    - Moderate CEF Scenario = -491 ($2.4 billion)

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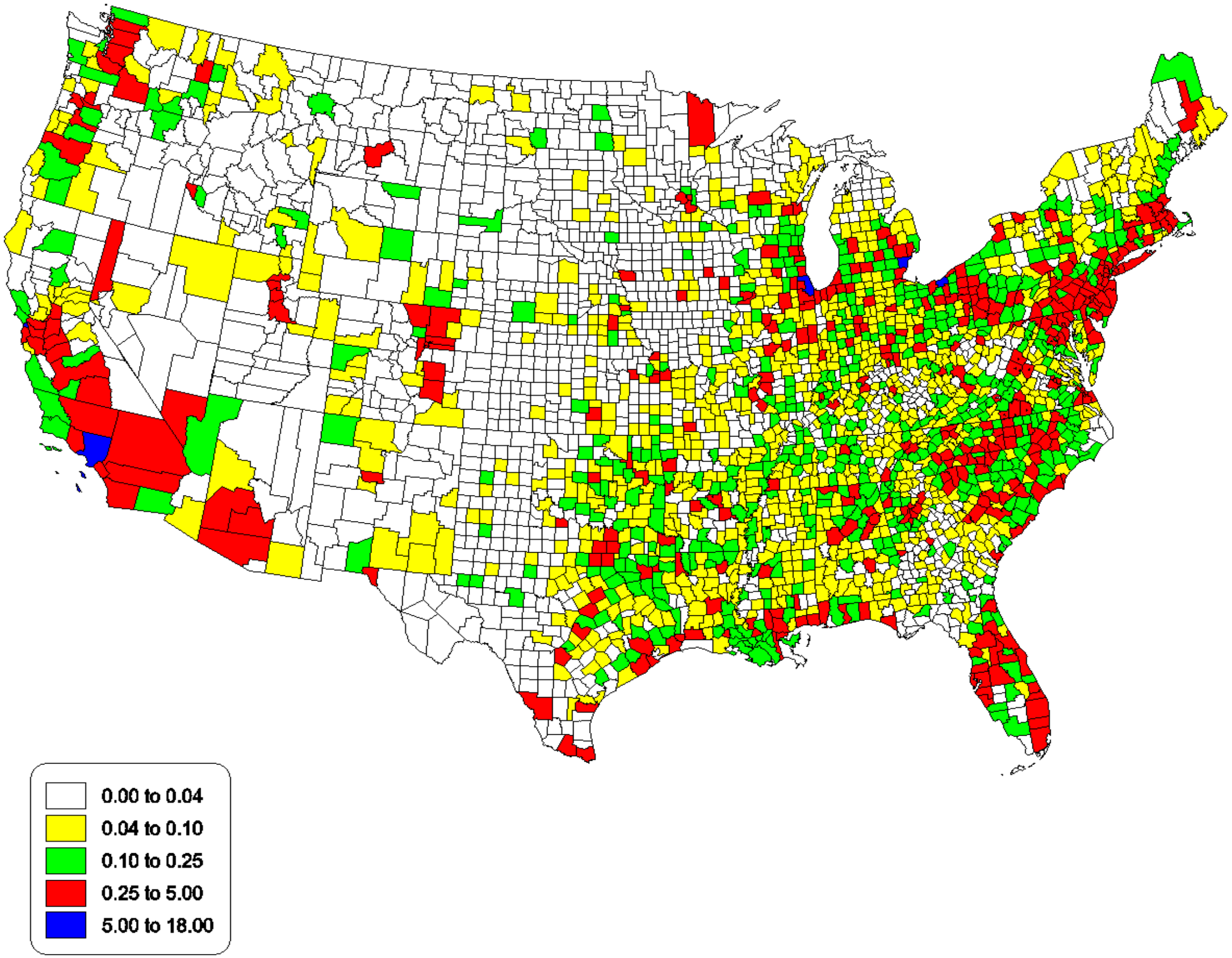
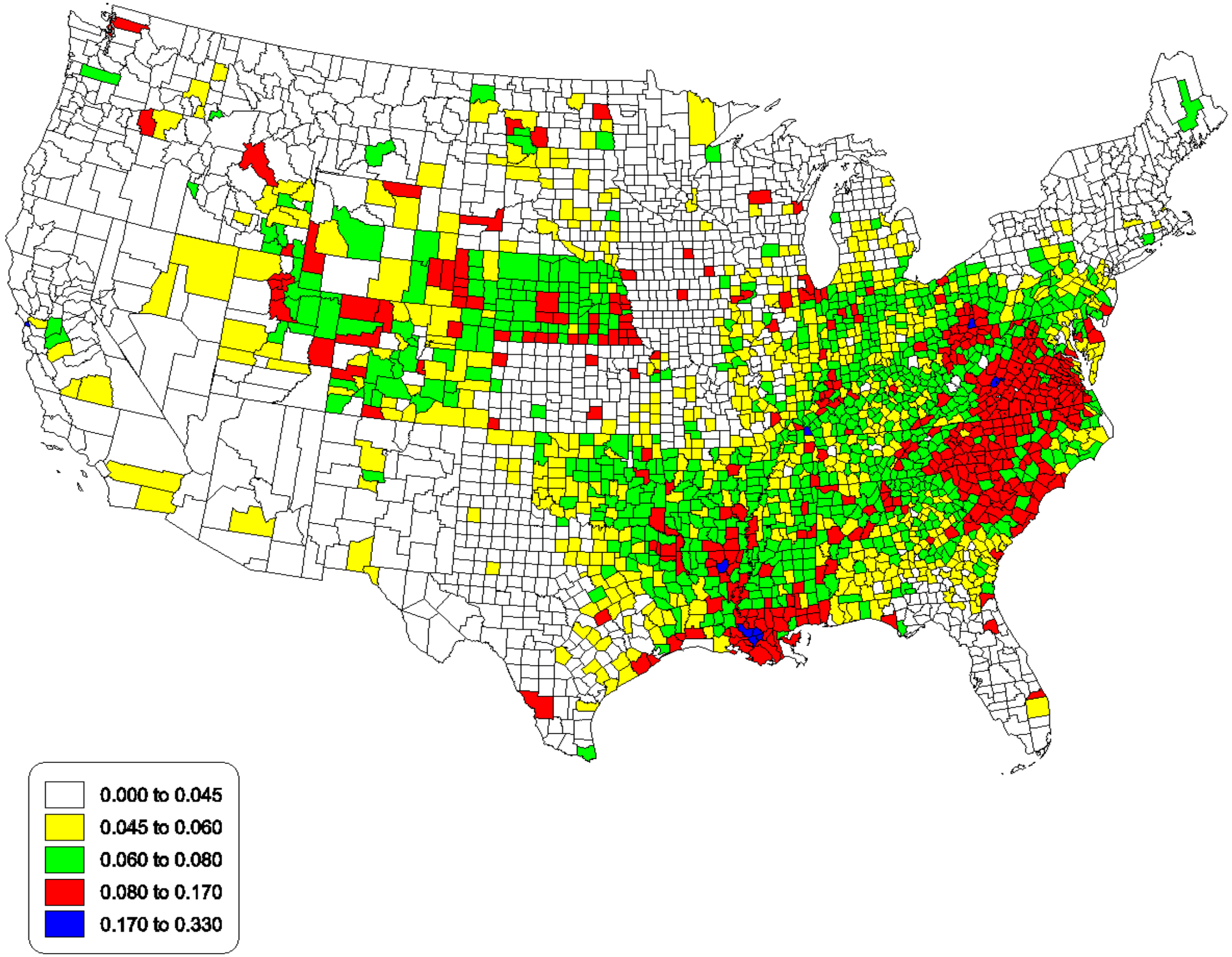
Advanced CEF – Excess Mortality



Moderate CEF – Excess Mortality



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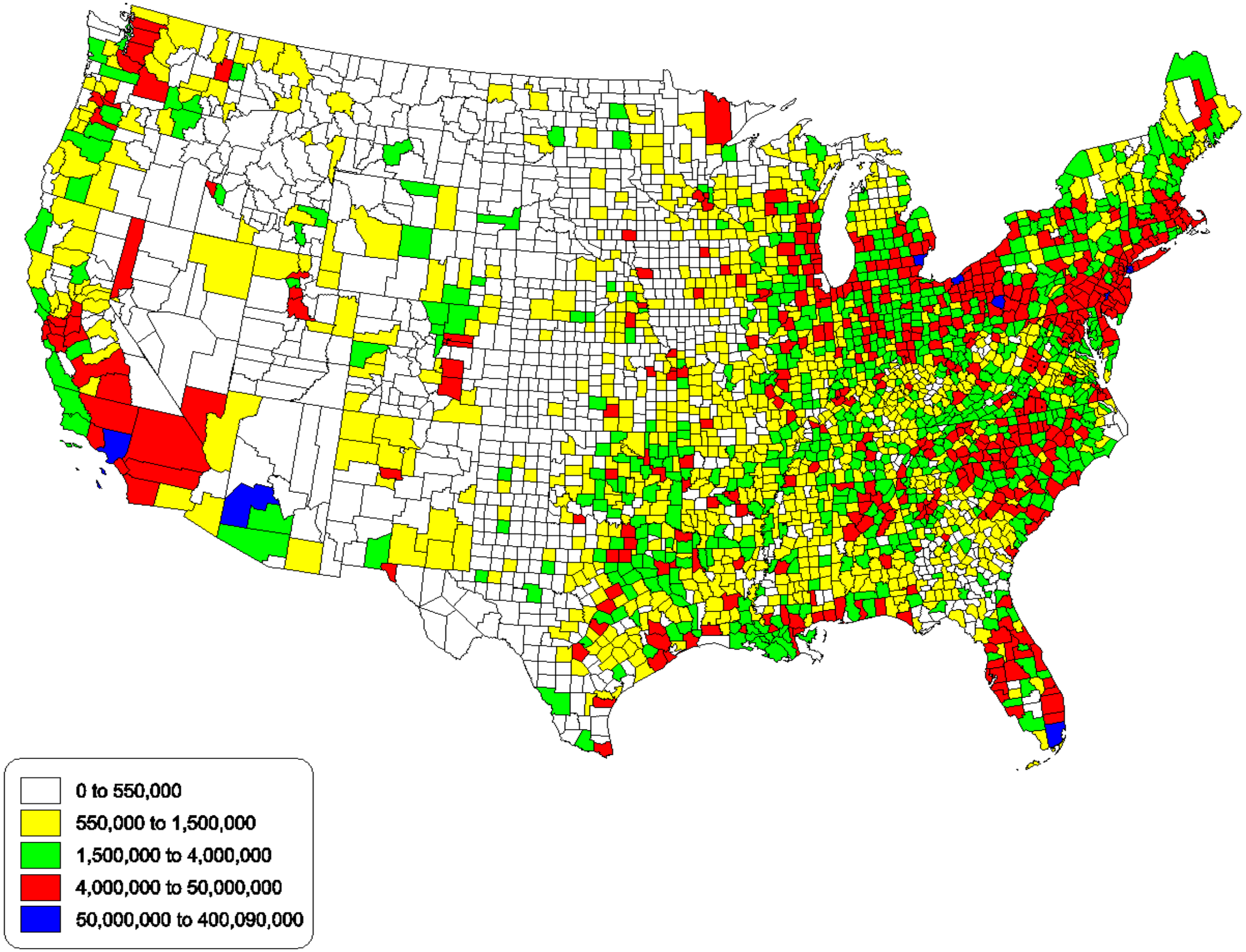
Advanced CEF - Valuation of Excess Mortality ($)



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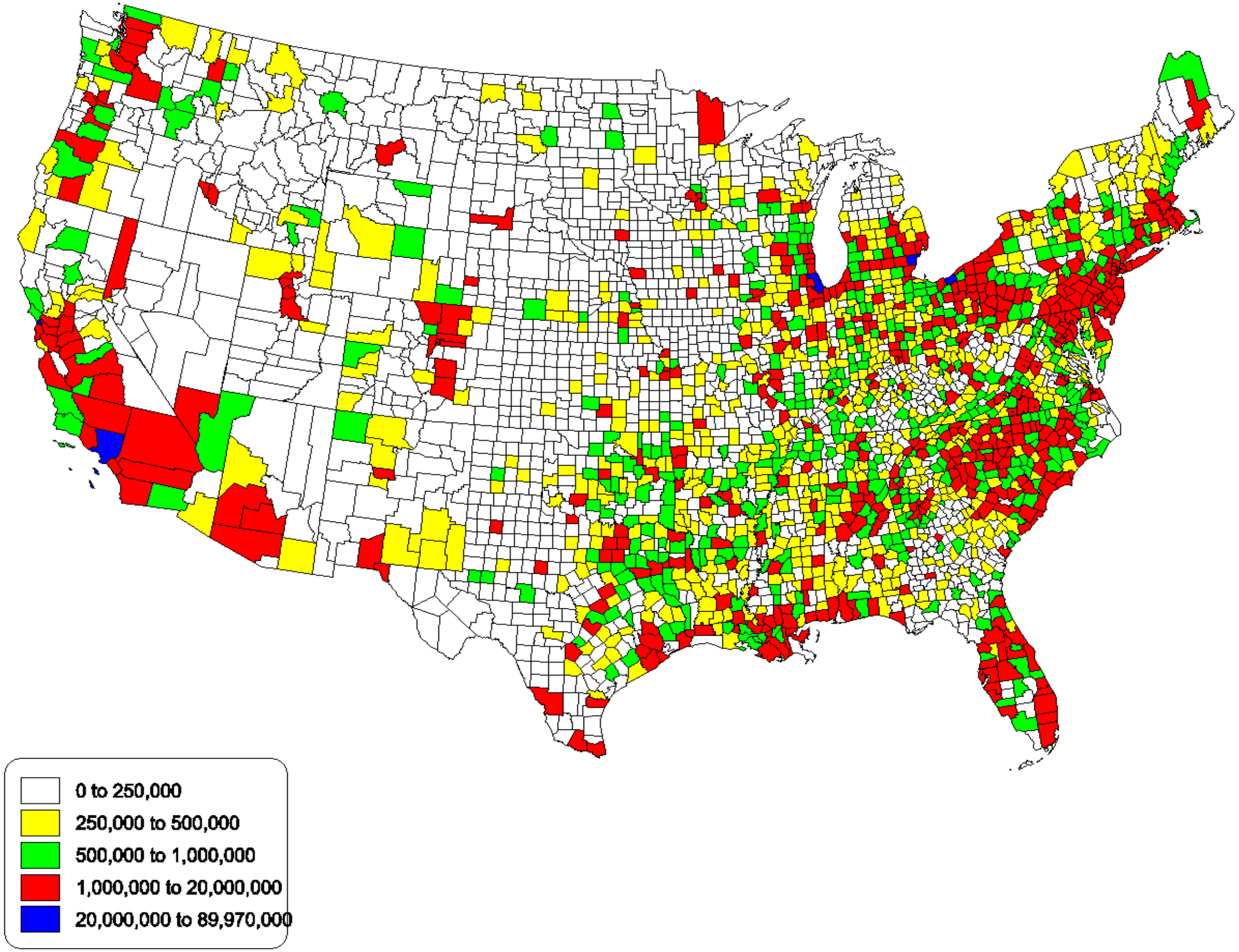
Moderate CEF - Valuation of Excess Mortality ($)



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Nitrogen Deposition into East- and Gulf-Coast Estuaries

Many coastal communities have concluded that sustainability of estuaries is dependent upon reducing nutrient (especially nitrogen) loadings entering the watershed

Methodology:

- Assign county-level NOx emissions reductions due to implementation of Climate Policy to watershed-specific airsheds
- Develop source-receptor coefficients to determine how changes in NOx emissions relate to nitrogen deposition loading
- Separate coefficients were calculated for local and regional effects to acknowledge the greater impacts local emissions have on deposition
- Calculate nitrogen deposition benefit (kg/year reduced) by combining watershed specific local and regional coefficients with NOx reductions

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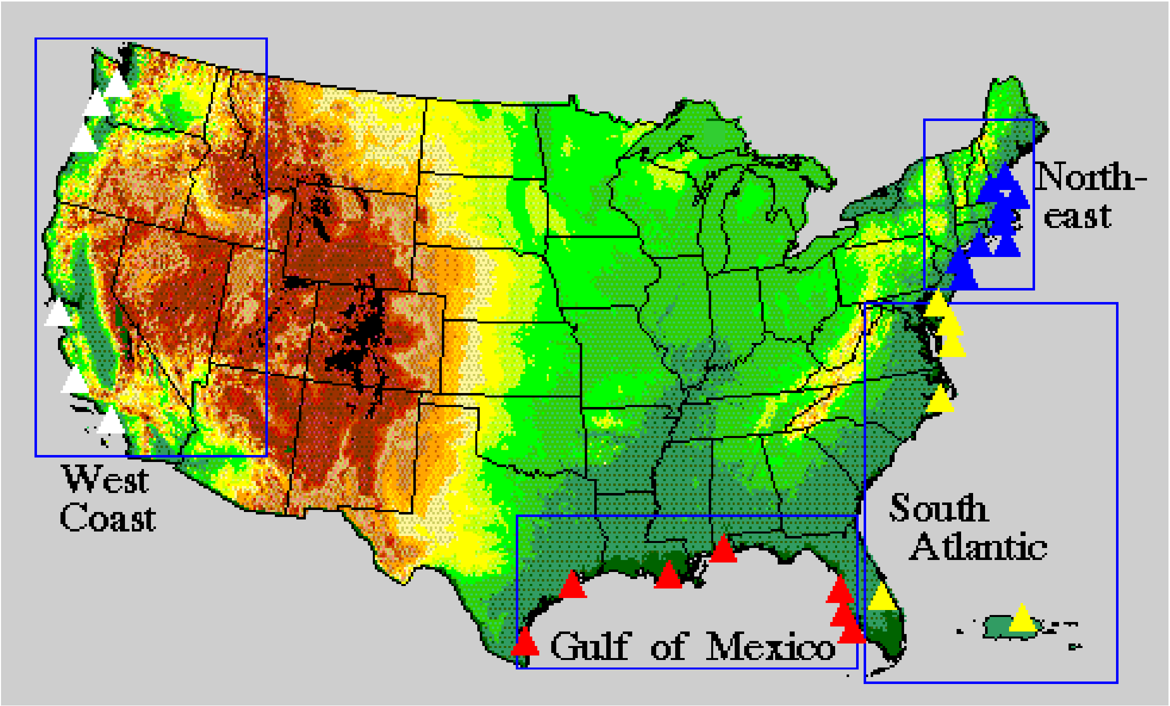
East- and Gulf-Coast Estuaries



- Albemarle/Pamlico Sound
- Cape Cod Bay
- Chesapeake Bay
- Delaware Bay
- Delaware Inland Bays
- Gardiner's Bay
- Hudson River/Raritan Bay
- Long Island Sound
- Massachusetts Bay
- Narragansett Bay
- Sarasota Bay
- Tampa Bay

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Reduction in Nitrogen Deposited in Estuaries (millions kg/year)

	Advanced Scenario				Moderate Scenario			
Estuary Name	**Local**	**Regional**	**Total**		**Local**	**Regional**	**Total**	
Albemarle/Pamlico Sound	0.39	0.76	1.14	10.1%	0.15	0.42	0.58	5.1%
Cape Cod Bay	0.09	0.30	0.39	10.4%	0.04	0.16	0.20	5.3%
Chesapeake Bay	0.72	1.20	1.92	11.1%	0.36	0.64	0.99	5.7%
Delaware Bay	0.10	0.22	0.31	9.8%	0.07	0.11	0.18	5.6%
Delaware Inland Bays	0.03	0.04	0.06	15.2%	0.01	0.02	0.03	7.8%
Gardiner's Bay	0.04	0.10	0.13	11.4%	0.02	0.05	0.07	5.9%
Hudson River/Raritan Bay	0.12	0.24	0.36	9.5%	0.08	0.12	0.20	5.4%
Long Island Sound	0.13	0.35	0.49	8.8%	0.06	0.19	0.24	4.4%
Massachusetts Bay	0.02	0.10	0.12	9.7%	0.01	0.05	0.06	4.9%
Narragansett Bay	0.03	0.09	0.11	10.2%	0.01	0.05	0.06	5.3%
Sarasota Bay	0.02	0.02	0.04	11.0%	0.01	0.01	0.03	7.2%
Tampa Bay	0.11	0.08	0.18	8.3%	0.06	0.04	0.10	4.6%
	1.78	**3.49**	**5.28**		**0.88**	**1.86**	**2.75**	

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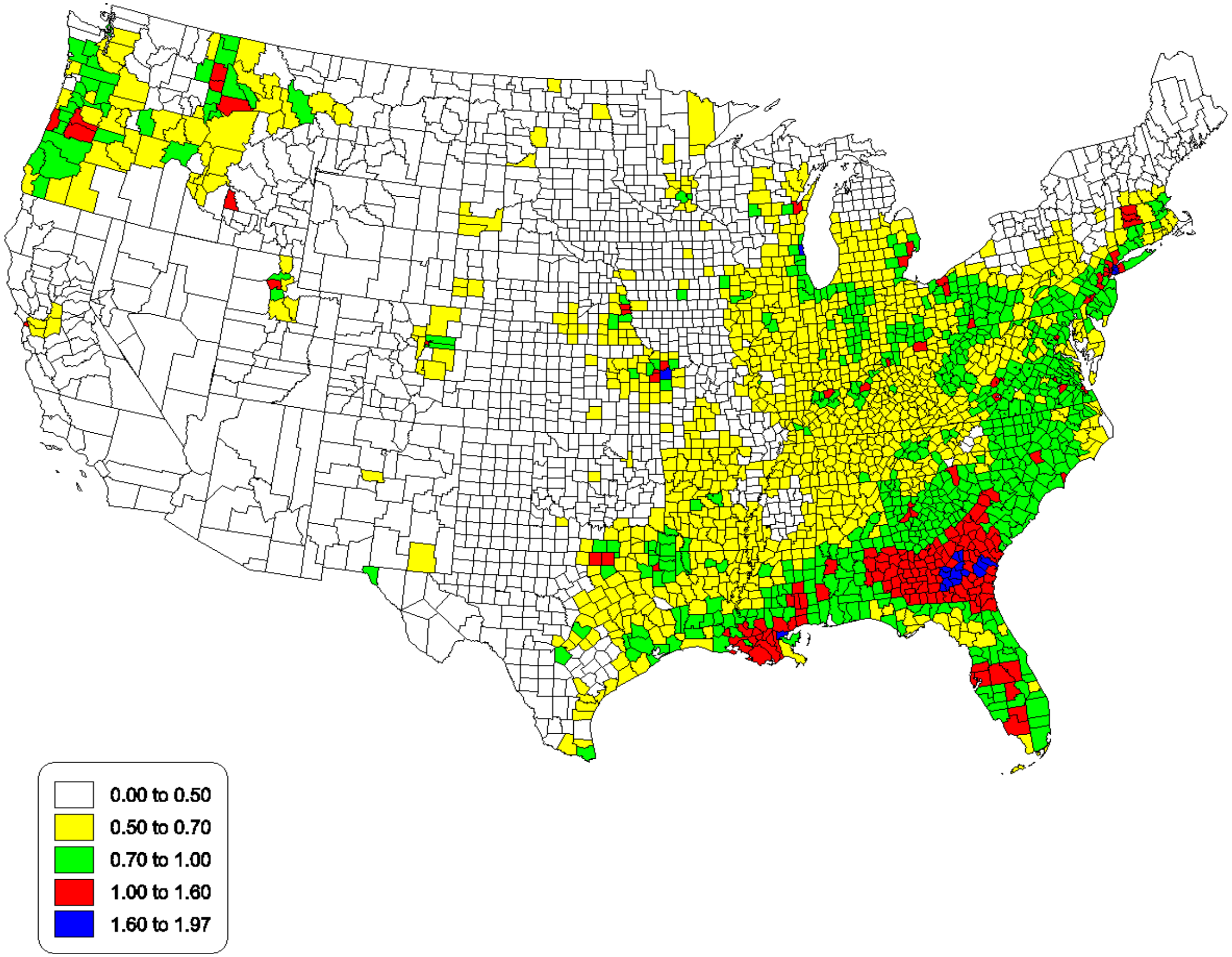
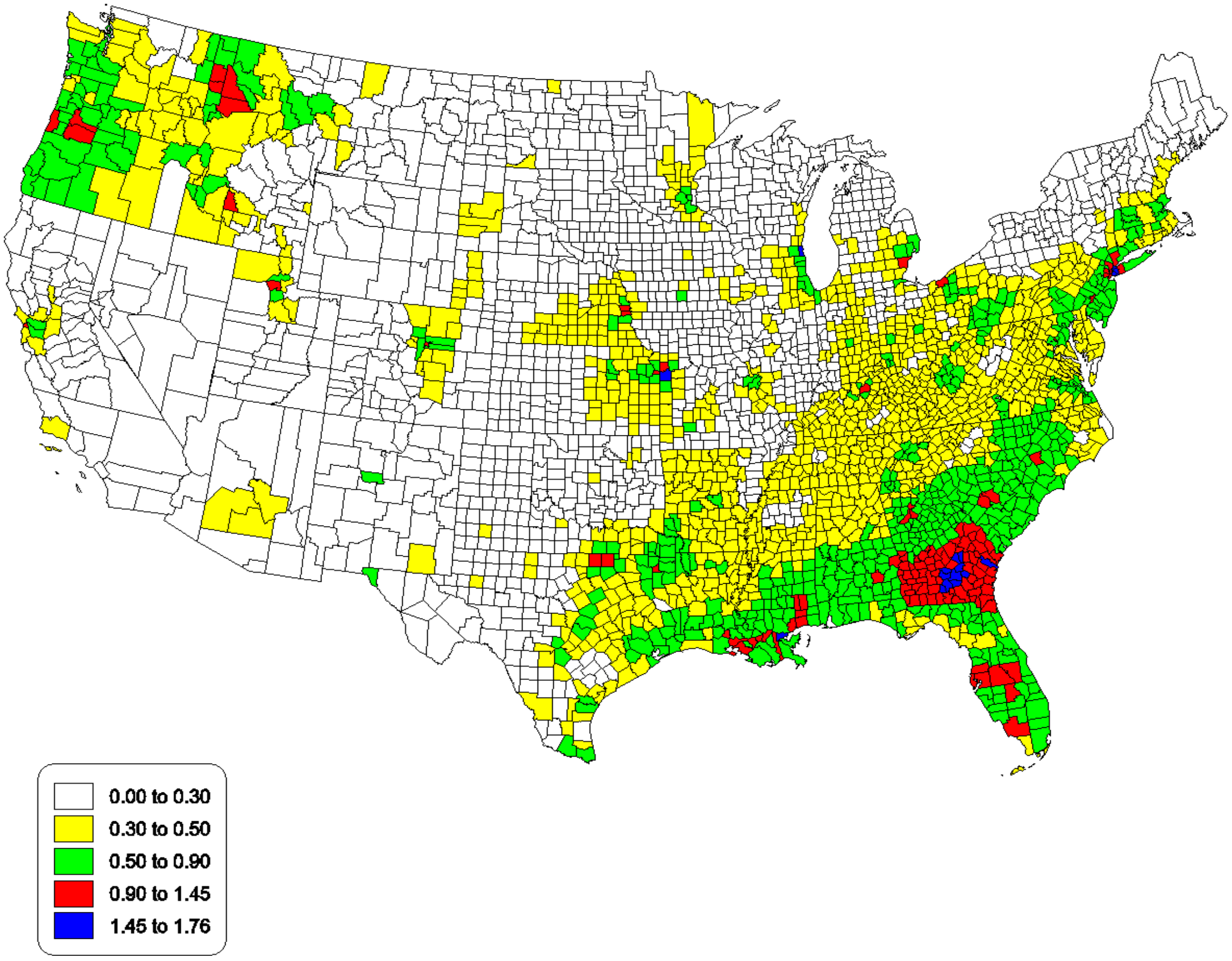
Visibility Improvements

- The total atmospheric light extinction can be estimated based on a knowledge of the atmospheric concentrations and physical properties of the light scattering or absorption species that contribute to light extinction
- The air quality concentrations for each scenario were used to relate pollutant concentrations to visibility extinction

Advanced CEF - Change in Visibility (deciview)



Moderate CEF - Change in Visibility (deciview)



Conclusions

- The air quality, health, and monetized co-benefits associated with the Clean Energy Future Scenarios are likely to be significant
- Policy analyses that omit co-benefit impacts will tend to underestimate the benefits of climate mitigation strategies

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